



REVIEW ARTICLE

Analysis of Independent Risk Factors of Surgical Site Infection in Neurosurgery and Study on Infection Prediction

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Abstract: Surgical site infection (SSI) is a common postoperative complication. Once patients suffer from SSI, negative effects such as prolonged hospitalization time, higher hospitalization expenses, poor prognosis and even death, will develop. At the same time, SSI imposes a heavy burden on the medical system and consumes medical resources seriously. Therefore, effectively monitoring and actively preventing SSI are particularly important.

Keywords: Neurosurgery; Independent Risk Factors; Analysis

1. Current situation of surgical site infection

Surgical site infection (SSI) refers to infection that occurs at or near the surgical incision site within 30 days after surgery and 1 year after foreign body implantation, such as incision infection, brain abscess and peritonitis. Infection types include superficial surgical incision infection, deep surgical incision infection and organ (lacuna) infection.

SSI is an important nosocomial infection. The report from the World Health Organization shows that the nosocomial infection rate is 3%-21%, of which SSI accounts for 5%-34%. Incidence of SSI ranks the third in nosocomial infections, after respiratory tract and gastrointestinal tract infections. Different countries have slightly different SSI incidences and the proportions of all nosocomial infections that SSI accounts for. For example, in China they are ~15% and ~35%, while in the U.S. they are 14%-16% and 38%. Nosocomial infection control is an important measure for medical institutions to improve medical quality, while SSI prevention is the focus of nosocomial infection control.

Statistics at home and abroad indicate that the

overall incidence of SSI among surgical patients is 4%-20%. Among them, the incidence of SSI of type I incision is the lowest, then comes type II. Type III and IV incisions can be exceeding 10%. The incidence of SSI varies greatly in surgical types according to literature reports: higher in craniocerebral operation and abdominal organ surgery, lower in obstetrics and gynecology.

In the United States, SSI occurs in 30.5 million operations every year, which accounts for 2%-5% of the total number of operations and causes a prolonged average hospitalization time (by 7 days) and an increased cost (by 3,000-50,000 US dollars). At the same time, the death rate of patients tripled and the readmission rate increased by 5 times. Broex *et al.* conducted a meta-analysis of literature about SSI published between 2004 and 2008, the results of which showed that compared with non-SSI patients, expenses of SSI patients increased by 34%-226%, and their hospitalization time prolonged by 48%-310%. Some domestic studies also showed that the hospitalization expenses of SSI patients were obviously higher and hospitalization time was longer than those of non-SSI

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patients. Early studies by British scholars indicated that 77% of surgical deaths were related to SSI. The burden of SSI on the country is considerable as well. The medical expenses provided by the British National Medical Center for SSI reached 1 billion pounds, which did not include indirect losses such as social care. Therefore, it is obvious that SSI not only causes heavy burden to the patients, but also consumes massive social resources.

2. Etiology and epidemiology of surgical site infection

The pathogenesis of SSI is based on the invasion of microorganisms to the surgical site. The type of pathogenic bacteria, virulence and immune function of patients are the key factors that determine whether SSI occurs or not. The risk of SSI can be expressed by the formula: SSI risk = bacterial contamination dose \times virulence / patient's immunity. When the microorganism per gram of tissue at the surgical site exceeds 10, the risk of SSI will significantly increase. However, if foreign bodies (such as silk sutures) exist at the surgical site, the amount of microorganism causing infection will be greatly reduced.

Pathogens causing SSI mostly originate from endogenous flora in patients' skin, mucosa or hollow organs. Common pathogens include both Gram-positive bacteria (e.g. *Staphylococcus aureus* and Coagulase-negative *Staphylococcus*) and Gram-negative bacteria (e.g. *Escherichia coli* and *Klebsiella pneumoniae*). Studies abroad have found that among SSI pathogens, *Escherichia coli* accounted for 23.9%, Coagulase-negative *Staphylococcus* for 22.8%, *Enterococcus* for 13.15%, and *Staphylococcus aureus* for 11.9%. The dominant pathogens varied from one surgical site to another. A study with large samples showed that *Staphylococcus aureus* and Coagulase-negative *staphylococcus* dominated sites of cardiac surgery, neurosurgery, breast surgery and vascular surgery, while Gram-negative bacteria and anaerobes dominated sites of abdominal surgery and urological surgery because these sites were close to perineum or groin. Investigations reveal that the proportion of SSI caused by fungi is also high, increasing with the incision depth. The detection rate of SSI resistant bacteria was relatively high, too.

Common SSI resistant bacteria included *Staphylococcus aureus*, *Enterococcus*, *Escherichia coli* and *Pseudomonas*, among which the detection rate of Methicillin-resistant *Staphylococcus aureus* (MRSA) was as high as 44.9%. SSI resistant strains make the treatment of SSI patients face severe challenges and seriously threaten their lives. As shown in studies abroad, the death rate of SSI patients infected by MRSA was up to 74%. Therefore, there is positive significance for the treatment and recovery of SSI patients to implement active and effective measures to delay the development of drug resistance of SSI pathogens.

3. Risk factors of surgical site infection

As the research on SSI moves along, a series of risk factors have been discovered, which can be divided into two categories: patient factors and surgery-related factors.

3.1 Patient factors

3.1.1 Age

It is generally recognized that children and the elderly are susceptible to infection due to lower immunity. Domestic literature reported that incidence of SSI was relatively high when patients underwent abdominal surgery younger than 15 and older than 60. Studies abroad also supported that. In series of studies by Kaye *et al.*, for patients aged 17-65 years old, the incidence of SSI increased by 1.1% ($P = 0.002$) for every 1 year of age increase, but decreased by 1.2% ($P = 0.008$) for every 1 year of age increase for patients undergoing surgery aged >65 years old. However, studies abroad showed that there was no significant difference in the incidence of SSI at the age >70. Therefore, the relationship between age and the SSI incidence requires further research.

3.1.2 Obesity

Studies abroad revealed that obesity was another important risk factor. When body mass index (BMI) reached 30 kg/m² or more, the incidence increased significantly ($P = 0.03$). Fat in incision of obese patients was prone to liquefy and form dead cavity after operation, which delayed incision healing.

3.1.3 Malnutrition

Preoperative malnutrition of patients will lead to poor incision healing after operation, quite easily causing infection. The incidence of SSI can reach as high as 22%-25% when severe malnutrition occurs.

3.1.4 Preoperative hospitalization time

Gong *et al.* found that the longer the preoperative hospitalization time, the higher the probability of contact with hospital pathogens, and the higher the incidence of SSI. The incidence was 0.05% when the preoperative hospitalization time was <3 days, while reached 3.08% when the preoperative hospitalization time was >8 days. Another investigation into cases of type I incision infection revealed that the length of preoperative hospitalization time was related to the occurrence of SSI.

3.2 Surgery-related factors

3.2.1 Preoperative skin preparation

Preoperative skin preparation can reduce the hair and the number of bacteria at the operation site, and reduce the occurrence of postoperative SSI. However, using razor to prepare the skin, compared with other methods e.g. cutting off, will significantly increase the incidence (RR: 2.09, 95% CI: 1.15-3.80). Using depilatory instead, can obviously reduce the occurrence (RR: 1.53, 95% CI: 0.73-3.21).

3.2.2 Environment of the operation room

Maintaining a sterile environment of the operating room such as surgical incisions, surgical instruments and surgical personnel can minimize the exposure to microorganisms, which is conducive to reducing the rate of surgical infection.

3.2.3 Surgical instruments

Surgical instruments like surgical clothing and sterile towel are in direct contact with the incision of patients. If they are not strictly sterilized, bacterial infection or even SSI may easily occur. The surgical clothing and sterile towel have separation effect, which can reduce the spread of microorganisms carried by the operator to the patient and reduce the chance of infection.

4. Summary

SSI is a common postoperative complication and one of the important types of nosocomial infection. To implement effective measures to prevent SSI has

always been one of the focuses of nosocomial infection control. Patient factors and surgery-related factors in risk factors of SSI are mostly controllable, adjustment of which can reduce the incidence of SSI.

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